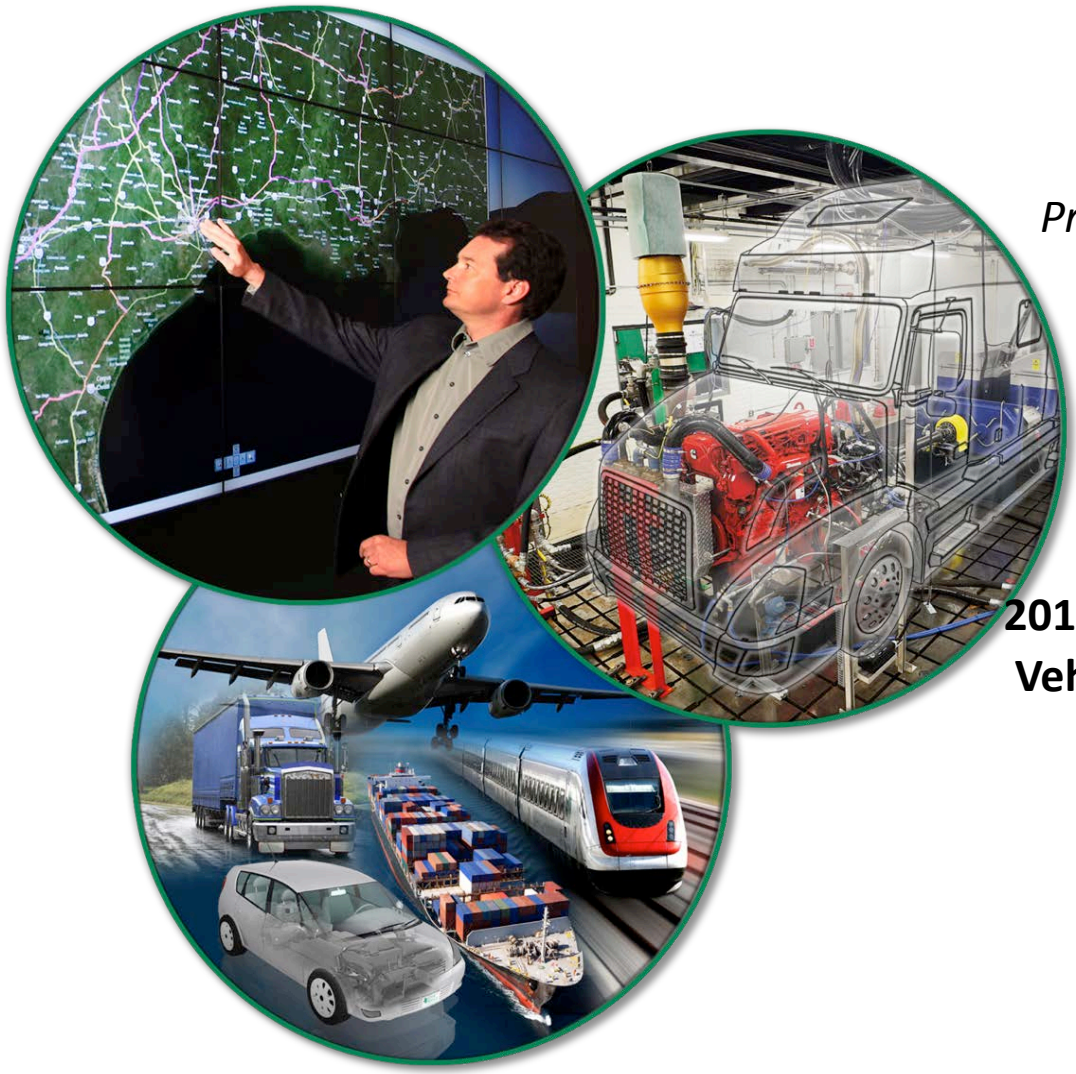
Transportation Energy Transition Modeling and Analysis: the LAVE-Trans Model



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2015 U.S. DOE Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting

June 11, 2015

Project ID: van013

Center for Transportation Analysis

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OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

OVERVIEW

Timeline

- Project start date: Oct. 2014
- Project end date: Continuing

Barriers/Targets*

- Understand the role of DOE VTs in an energy transition
- Costs of advanced powertrains
- Behavior of manufacturers and consumers
- Infrastructure
- Incentives, regulations and other policies

**from 2011-2015 VTP MYPP*

Budget (DOE share)

- FY14 funding: $100k
- FY15 funding: $100k

Partners

- NRC Committee on "Transitions to Alternative Vehicles and Fuels" (2013)
- The International Council on Clean Transportation (ICCT)
- University of Tennessee
- Argonne National Laboratory

Relevance

Objectives of LAVE-Trans Project

- Understand the transportation energy transition process by modeling the interplay between technologies, consumer market, policies, and infrastructure.
- Assess the potential of vehicle technologies in meeting the goal of petroleum and CO2 reduction
- Quantify the costs and benefits of the transition
- Provide guidance to the transition

Addressing Barriers

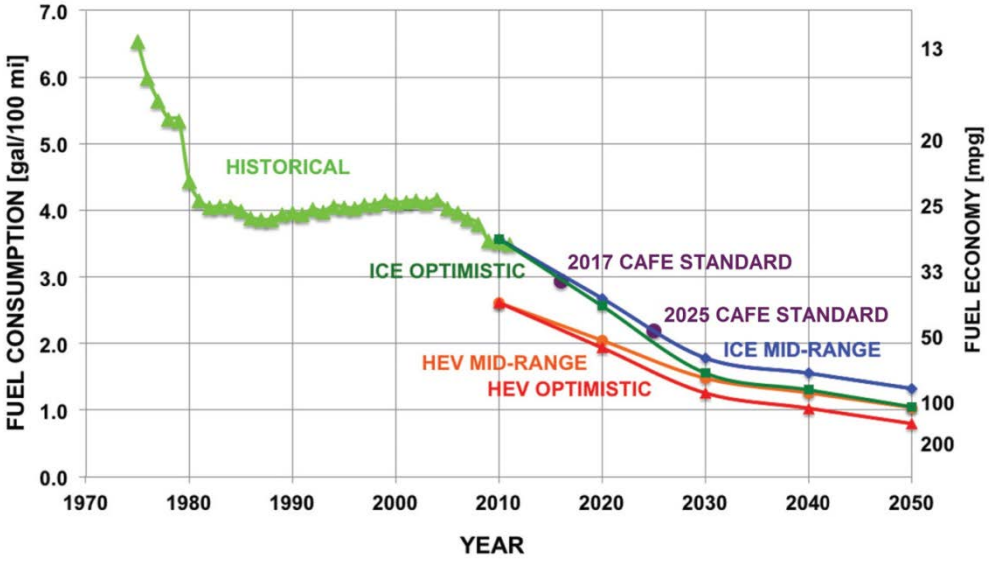
- Explicitly model transition barriers (e.g. higher technology cost, lack of infrastructure) and evaluate the role of policy strategies in overcoming barriers

Relevance

Originally developed and used for NRC study (2013)

- Evaluate the potential of transition scenarios in meeting the 2050 goal of CO2 emissions and petroleum consumption reduction

Continuously improving energy efficiency appears to be a necessary strategy

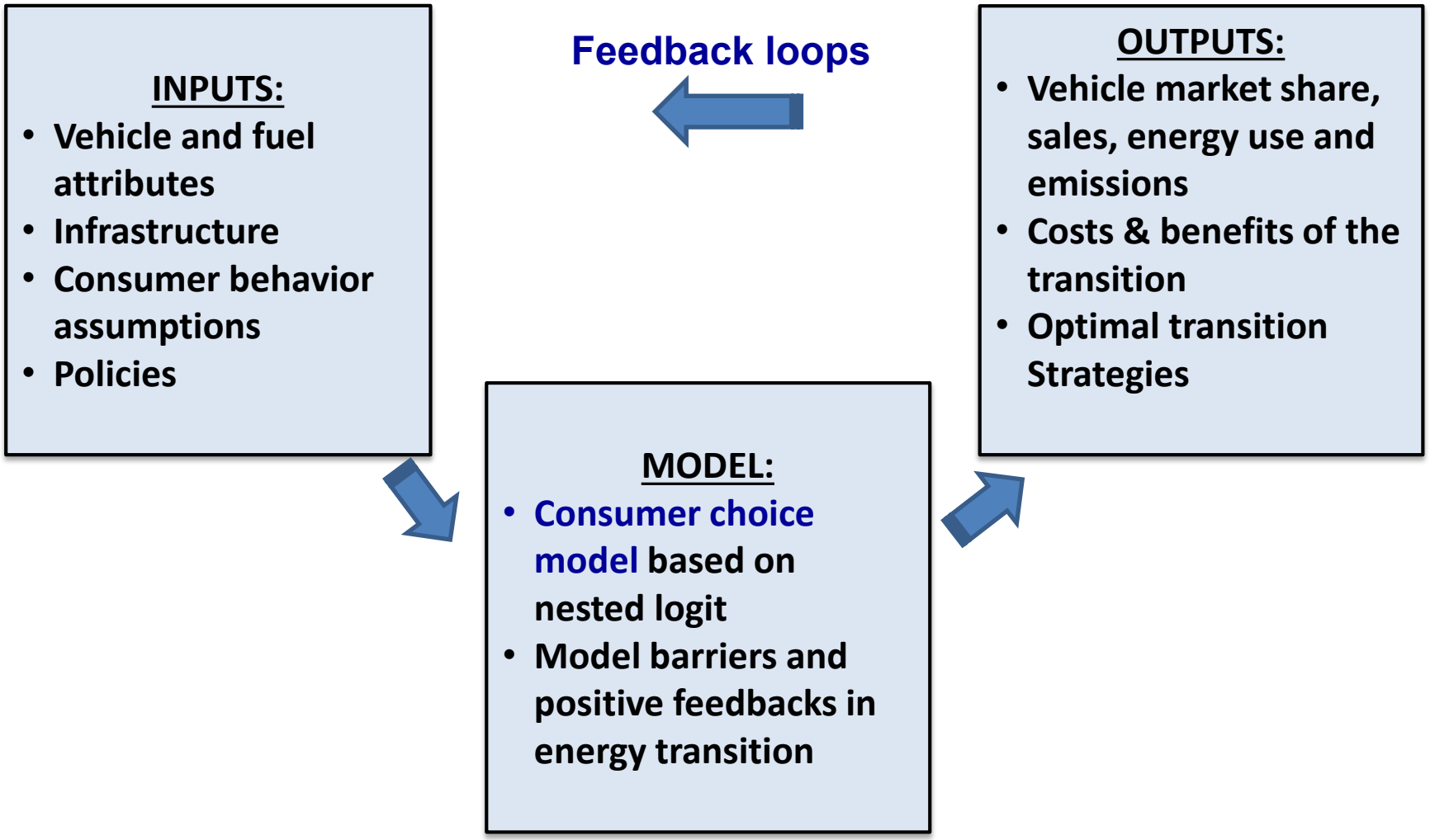


Further development under DOE support

- An alternative consumer choice model for model comparison and cross validation
- Understand the role of DOE vehicle technologies in the context of the energy transition and related costs and benefits

National Research Council (2013). Transitions to Alternative Vehicles and Fuels. Washington, DC: The National Academies Press..

Approach: Built upon discrete choice theory, the LAVE-Trans model represents and quantifies the key processes and barriers to the transition, including many positive feedback loops.



Approach: LAVE-Trans models and tracks major market barriers of the transition and network external benefits (positive feedbacks) of overcoming barriers

Market Barriers:

- Lack of Infrastructure
- Higher upfront purchase cost
- Lack of make & model diversity
- Risk aversion
- Current technology limitation (limited range, long charging time)

Positive Feedbacks: Increased vehicle sales will

- Enhance infrastructure viability
- Reduce vehicle production cost via manufacturers' scale economy and learning by doing
- Increase make & model diversity
- Reduce risk aversion of the majority

Self-reinforcing positive feedback effect may eventually lead to a self-sustained transition (It needs strong initial push).

Approach: LAVE-Trans recognizes the importance of policies to the success of the transition; strong and temporary subsidies/mandates are needed in the beginning.

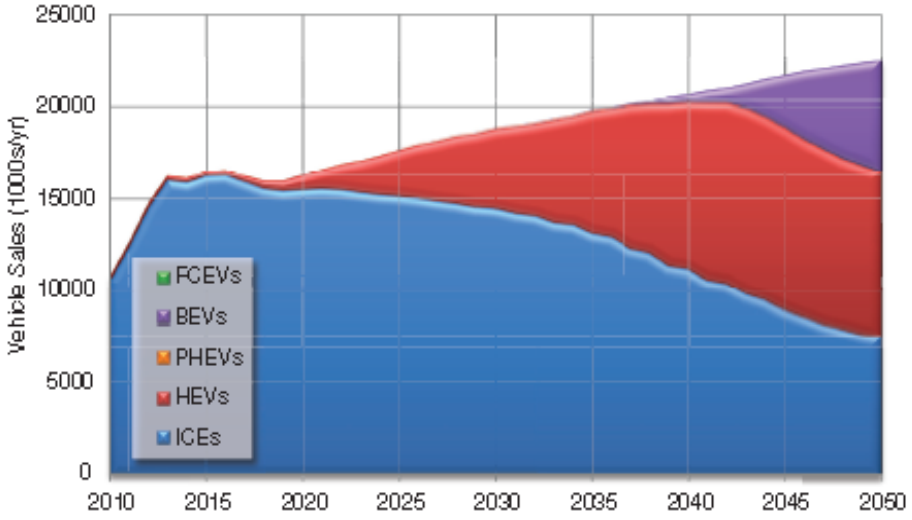
Base case assumptions:

- **2025 CAFE standards plus technological progress beyond 2025.**

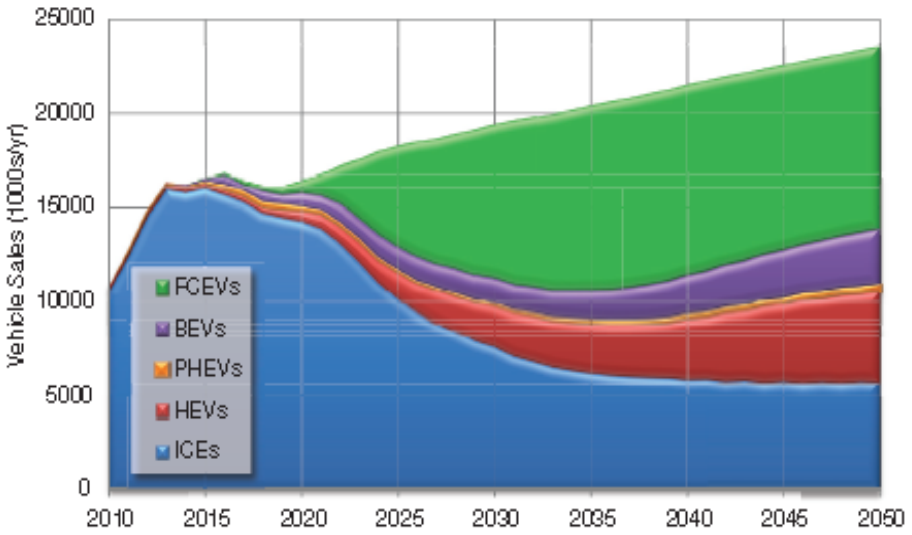
Policy case assumptions:

- **Base case + vehicle subsidies/mandates for a decade or so + early H2 infrastructure.**

Base Case Vehicle Sales



Policy Case Vehicle Sales



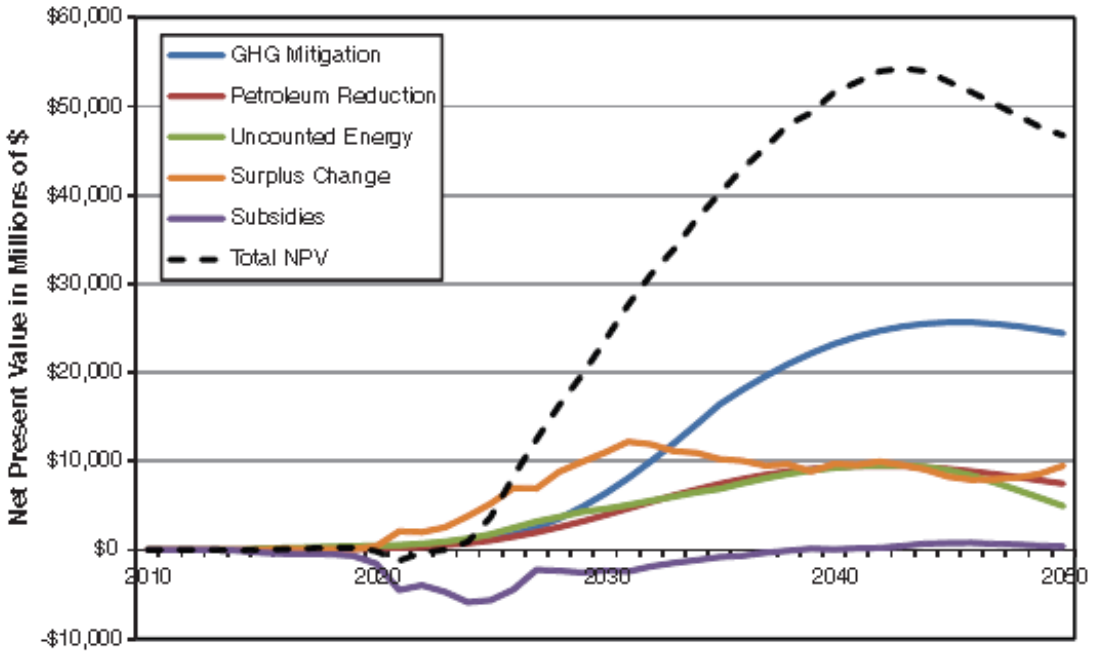
Approach: LAVE-Trans calculates the costs and benefits of the transition (by comparing a policy case with its base case)

Costs & benefits considered:

- Subsidies
- Consumer surplus change
- Energy savings
- Social value of reductions of emissions and petroleum consumption

Net Present Value (NPV) is the sum of all costs and benefits

- The figures illustrates a transition scenario with large positive NPV.



Technical Accomplishments in FY15

FY14 AOP Milestone	Due Date	Sub-task	Status as of 04/15/2014
Model Update	03/31/ 2015	Update with AEO 2014 & latest Autonomie results	Completed
Model Enhancement	06/30/ 2015	Develop algorithms to calibrate the model to historical data	Completed
		Literature review & Improve representation of energy supply infrastructure	On schedule
Analysis	06/30/ 2015	Preliminary results on analyzing the impact of DOE vehicle technologies	On schedule
Reporting	09/30/ 2015	Submit a technical report or journal paper	On schedule

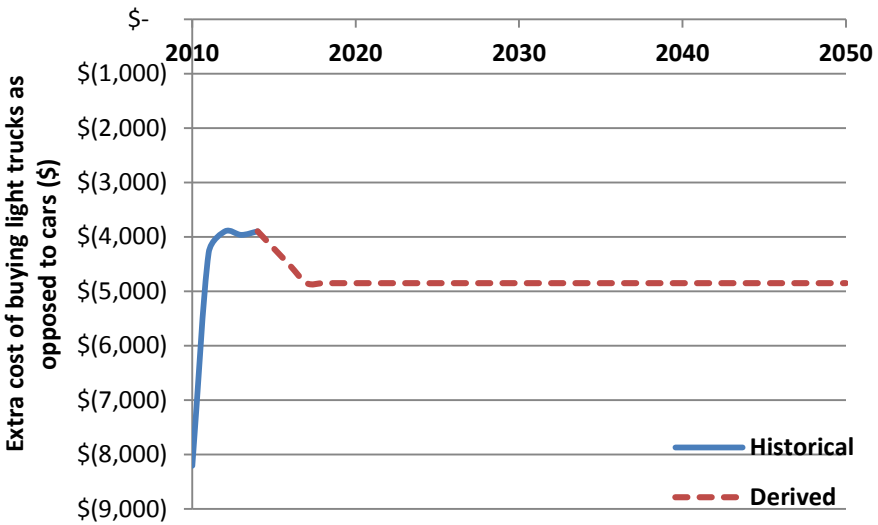
Publications & Presentations

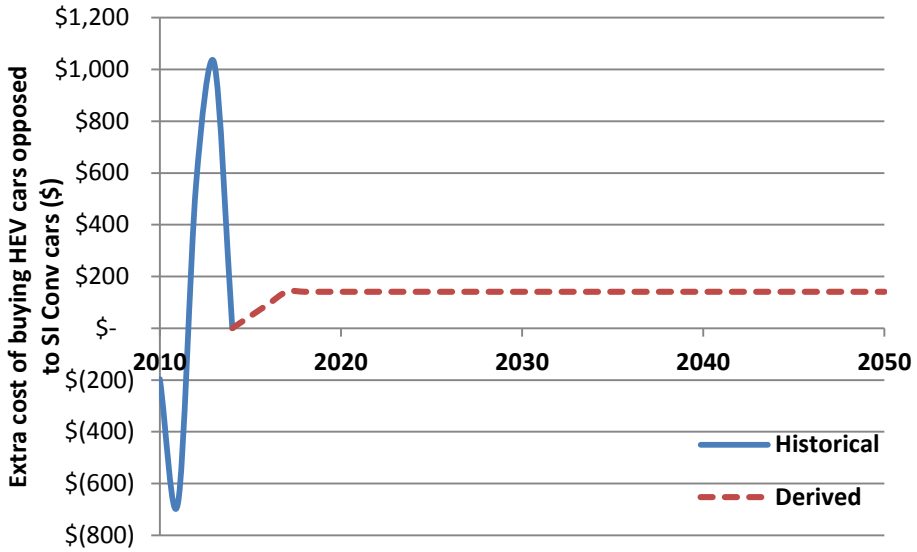
- **Alternative Transportation Refueling Infrastructure in the U.S. 2014: Status and Challenges, White Paper 1-15, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, Knoxville, January, 2015.**
- **Greene, D. L., S. Park, and C. Liu (2014). Public policy and the transition to electric drive vehicles in the US: The role of the zero emission vehicles mandates, *Energy Strategy Reviews*, 5, pp. 66-77.**
- **"Optimal Electric Vehicle Charger Placement Problem: A Time-of-Day Parking Activity Based Approach", Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, San Francisco, USA, November 2014.**

Technical Accomplishments: Algorithms are developed to calibrate LAVE-Trans to historical data; Calibrated constants reveal consumer preference that is not captured by explanatory variables

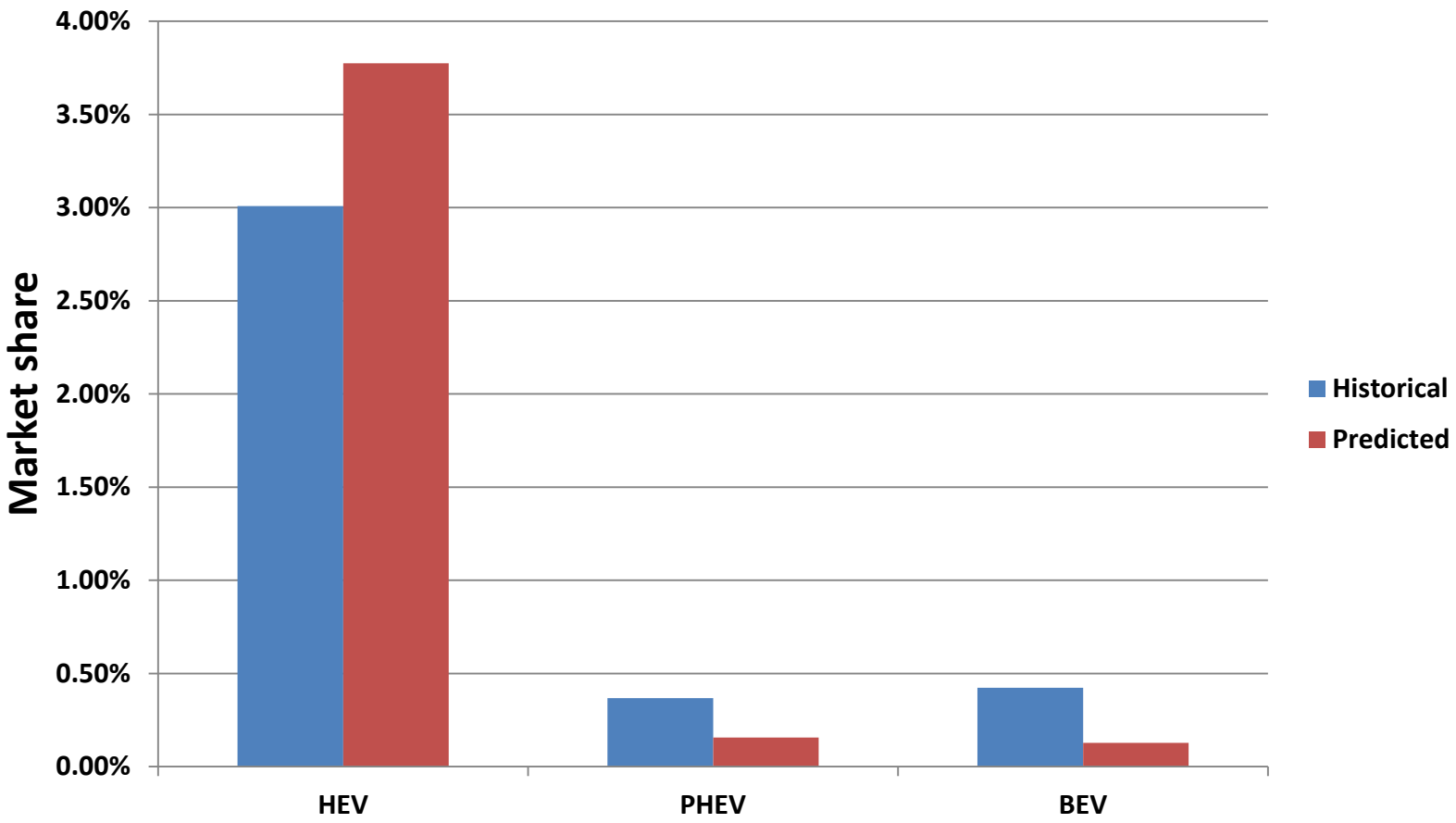
Calibration:

- **Adjust Buy/no buy constants to match total LDV sales**
- **Adjust car/truck constants to match car/truck share**
- **Adjust technology specific constants to match historical share**
- **Average constants are used for outer year projection**

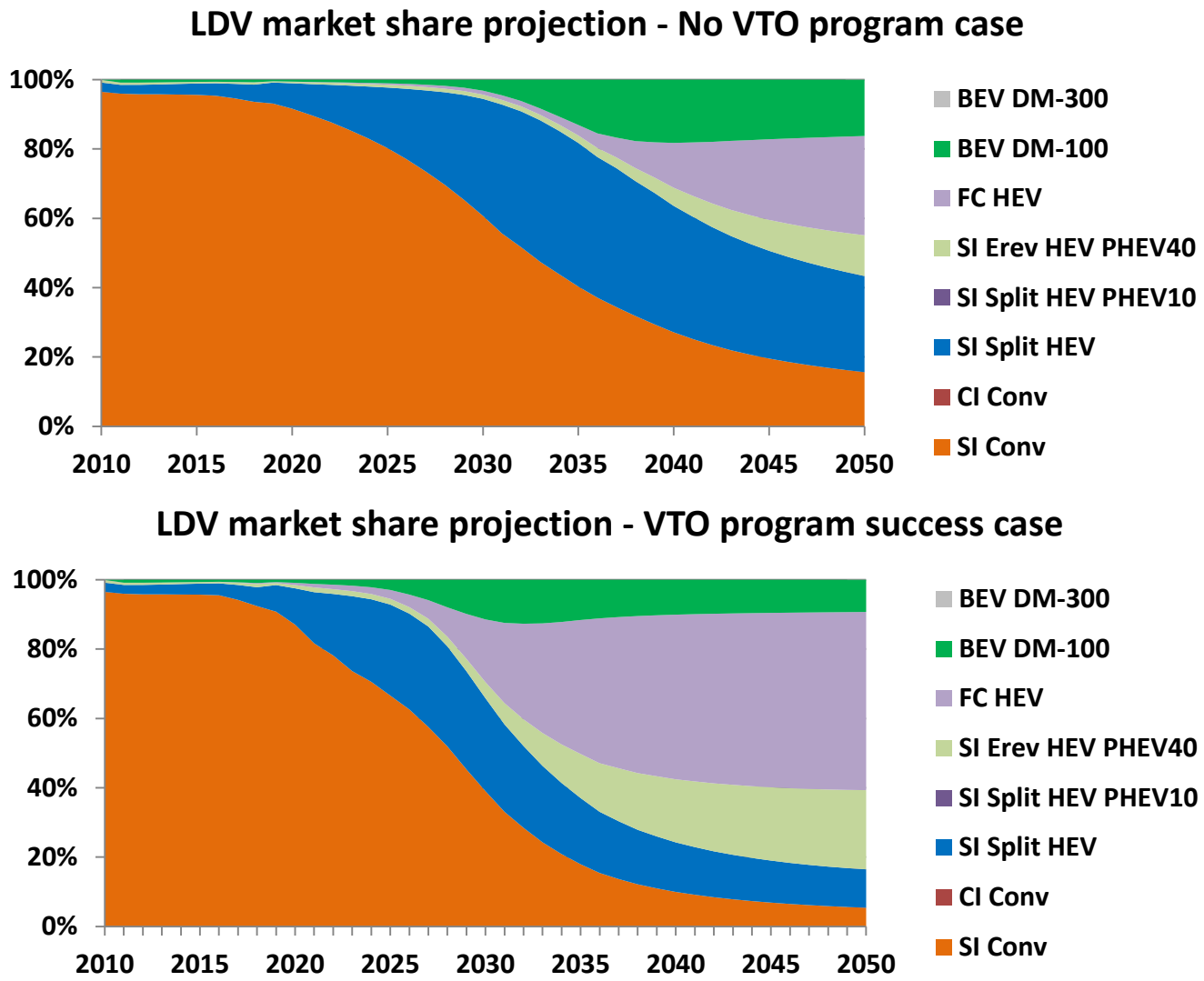




Technical Accomplishments: Validation effort is made to backcast 2014 market share using the average constants for 2011- 2013



Technical Accomplishments: The model is used to support DOE GPRA analysis; VTO vehicle technologies have enabled faster and higher penetration of alternative fuel vehicles



COLLABORATION AND COORDINATION

- **National Research Council (NRC) committee on "Transitions to Alternative Vehicles and Fuels"**
  - Providing data and numerous feedbacks on model assumptions and results
- **The International Council on Clean Transportation (ICCT)**
  - Providing data
  - Original sponsor of the model
- **David Greene, University of Tennessee**
  - model development and policy analysis
- **Tom Stephens and Yan Zhou, Argonne National Laboratory**
  - Providing data and assisting in model testing and comparison

PROPOSED FUTURE WORK

- **Remainder of FY2015**
  - **Finish the improvement of electric charging infrastructure representation**
  - **Support the DOE GPRA analysis by forecasting LDV market share under alternative scenarios**
  - **Submit a technical report or journal paper**
- **FY2016**
  - **Data update**
  - **Model Enhancement:**
    - **Further improve the representation of energy supply infrastructure**
  - **Comparison and cross validation with other DOE consumer choice models**
  - **Develop more insights of the transition by mathematical derivation**
    - **E.g., conditions of tipping points, strength of positive feedback**
  - **Decision making under uncertainty: explore robust and adaptive transition strategies by integrating LAVE-Trans and optimization**

Summary

- **Relevance: LAVE-Trans is a consumer choice model and transition costs/benefits analysis tool; the objective is to better understand the role of vehicle technologies in an energy transition.**
- **Technical Accomplishments:**
  - **The model has been Updated to AEO2014 and latest Autonomie results**
  - **Calibrated to historical data and validated by backcasting**
  - **Used to support DOE GPRA anaysis**
- **Future work will further improve the representation of energy supply infrastructure, develop more understanding of the transition process, and integrate the model with optimization.**

Thank you!